associated with the operation of both State, federal, and private facilities located throughout the ERPP study area. Immediately, programs will be undertaken that reduce the current level of predation related mortality associated with facilities within the ERPP study area.

RESTORATION ACTIONS

The general target is to develop and implement hatchery practices to reduce the potential interactions and competition between artificially produced and naturally produced chinook salmon, steelhead, striped bass, and other resident and estuarine fish. Predation and competition can be further reduced by restoring complex and diverse habitats throughout the mainstem rivers and Bay-Delta.

Actions which can contribute to this vision include:

- reducing shadows and turbulence created by dams, bridges, and diversions that attract predator species,
- replacing or supplementing rock revetment site with natural vegetation including shaded riverine aquatic habitats,
- restoring large blocks of riparian and shaded riverine aquatic habitats along the mainstem Sacramento and San Joaquin Rivers,
- preventing predatory fish from congregating below the Red Bluff Diversion Dam by modifying operations,
- improving fish passage through the flood control bypasses and eliminating low areas with no connection to perennial water courses,
- improving fish release sites used by the State and federal Delta fish salvage facilities,
- reevaluating opportunities to reduce predation in Clifton Court Forebay,
- evaluate alternate release strategies for Central Valley hatcheries to minimize interactions between hatchery and naturally produced fish,

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.
- To the extent consistent with Program objectives, manage operations at the Red Bluff diversion dam to improve fish passage, reduce the level of predation on juvenile fish, and increase fish survival.

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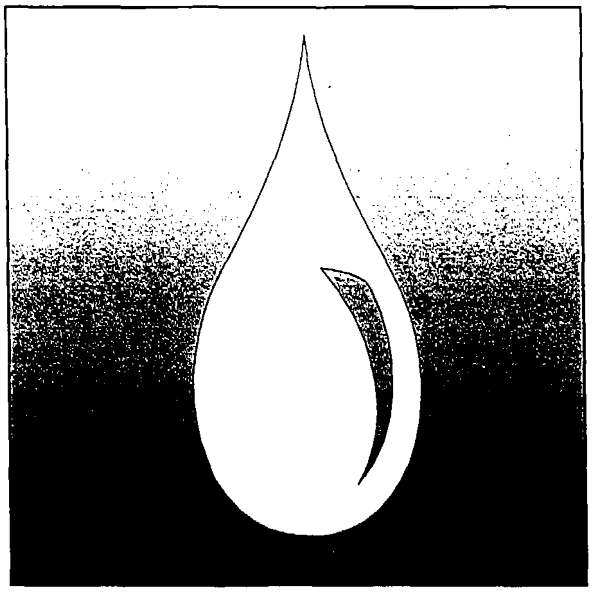

INTRODUCTION

Contaminants are inorganic and organic compounds and biological pathogens that introduce the risk of adverse physiological response in humans, plants, fish, and wildlife resources through waterborne or food-chain exposure. Contamination by these compounds may cause acute toxicity and mortality or long-term toxicity and associated detrimental physiological responses, such as reduced growth or reproductive impairment. Contaminant toxicity has been documented in shellfish, fish, mammal, and bird species from the Bay-Delta. The most serious contaminant problems in the Bay-Delta and its mainstem rivers and tributaries come from mine drainage, agricultural drainage, and urban runoff.

ERPP recognizes that water quality in the Delta must be protected and improved for all beneficial uses including municipal and domestic water supply, irrigation, stock watering, contact and noncontact water-related recreation, hydroelectric power generation, industrial service supply, warm and cold freshwater habitat, warmwater and coldwater spawning, fish migration, and wildlife habitats.

Although cause-and-effect relationships between levels of contaminants and the abundance of aquatic resources have not been conclusively documented, ERP envisions a restored, healthy Bay-Delta ecosystem in which contaminant loads and concentrations are reduced to levels that do not interfere with primary and secondary productivity, nutrient cycling, and foodweb support. Such a restored ecosystem would no longer necessitate human health warnings about consuming fish and wildlife caught in the Bay-Delta estuary.

STRESSOR DESCRIPTION

An estimated 5,000-40,000 tons of contaminants enter the Bay-Delta annually. They are distributed according to complex flow patterns that are heavily influenced by inflow from rivers and the amount of water being pumped from the Delta. Although research confirms that toxicants are affecting lower trophic-level resources to varying degrees in the Bay-Delta, ecosystem- and population-level effects are not well understood. Researchers disagree about the role that contaminants have played in the current poor health of the Bay-Delta.

There are four types of contaminants, inorganic, organic, biological, and toxicity of unknown origin present in the Bay-Delta ecosystem. Inorganic contaminants are substances such as heavy metals, phosphates, and nitrates that enter the Bay-Delta ecosystem primarily in treated municipal wastewater, industrial effluent, agricultural and mine drainage, and urban runoff. Heavy metals in the water column usually occur in trace amounts. They do not break down organically; however, even small amounts of some metals can be toxic. In addition, some metals bioaccumulate within food chains in plant and animal tissue to levels that can be toxic to higher trophic organisms. The heavy metals of greatest concern in mainstem rivers and tributaries of the Bay-Delta are cadmium, copper, mercury, and zinc.

Organic contaminants such as polychlorinated biphenyls (PCBs), plastics, pesticides, fertilizers, solvents, pharmaceuticals, and detergents enter the ecosystem primarily through urban and agricultural runoff. Because they decompose very slowly, some organic contaminants (e.g., DDT and PCBs) remain in the environment for long periods and may accumulate in aquatic foodwebs to levels that are toxic.

Biological pathogens, such as viruses, bacteria, and protozoans that cause disease, enter the system through improperly treated municipal sewage, septic systems, farm and feedlot runoff, recreational boat discharges, and urban runoff. Of particular concern to humans are bacteria that cause cholera, hepatitis, salmonella, and typhoid.

Elements causing toxicity in the Sacramento and San Joaquin river watershed and the Delta have not all bee identified in present evaluations. In approximately half of the toxicity tests conducted in the Sacramento River watershed, the toxicity detected in test species has not been linked to specific chemicals. This is also true for about 30% of the toxic samples collected in the Delta and San Joaquin River watershed.

Since 1986, the Central Valley Regional Water Quality Control Board and the California Department of Fish and Game have been testing the surface waters of the Central Valley for toxicity. Sediment testing has also occurred, but on a much more limited basis. Unknown toxicity is of significant concern because it indicates that there exit agents which are bioavailable and causing toxicity that remain to be identified. Unknown toxicity is also an issue for the Sacramento River Watershed and Delta because it leads to these water bodies not being in compliance with the Narrative Toxicity Objective of the Basin Plan.

Contaminants are present in varying degrees in the water column and sediments of aquatic habitats in all 14 ecological zones of the ERPP study area. Contaminants are suspected or known to adversely affect the sustainability of healthy aquatic foodwebs and interdependent fish and wildlife populations. They also may play a key role in altering the composition of biological resources within affected aquatic and wetland habitats.

In the Sacramento River Basin, acidic drainage water from abandoned mine tailings contribute significant amounts of cadmium, copper, zinc, and mercury to tributaries and mainstem rivers that eventually flow into the Delta. Acute toxicity caused by these trace metals has resulted in fish kills, and long-term exposure is detrimental to growth and impairs reproduction. Of immediate concern is the potential hazard associated with mine drainages just upstream of the spawning area for the endangered winter-run chinook salmon on the Sacramento River. Because of elevated mercury levels, the Bay-Delta, Clear Lake, and Lake Berryessa have consumer advisories for consumption of fish. There are various mercury sources in the Sacramento River watershed including abandoned mines and Coast Range geologic sources.

In the San Joaquin River Basin, selenium leaches into agricultural drainage water during intense irrigation of selenium-rich soils. Selenium has caused reproductive failure in sensitive fish species and developmental deformities in waterfowl and shorebirds. Selenium is also prevalent in the San Francisco Bay, resulting from oil refinery discharges. Loadings of selenium into the Bay-Delta have caused an increase in concentrations of these contaminants in benthic invertebrate, fish, and wildlife populations. Concentrations of some contaminants in water, sediments, and biota of the Bay-Delta estuary are elevated compared with levels at reference sites.

In the Sacramento and San Joaquin River basins, runoff from agricultural crops, pasturelands, and orchards has introduced contaminants into tributaries and mainstem rivers, which ultimately flow into the Delta estuary and Bay. Organophosphate insecticides, such as carbofuran, chlorpyrifos, and diazinon, are present throughout the Central Valley and are dispersed in agricultural and urban runoff. Dormant spray pesticides enter rivers in winter runoff and enter the estuary in concentrations that can be toxic to invertebrates. Although the use of these chemicals has been banned, organochlorine pesticides (e.g., chlordane, DDT, and toxaphene) and organochlorine compounds (e.g., PCBs) persist in the environment. Because they accumulate in living organisms, they can become potent toxicants to fish and wildlife as they move up through the foodweb. Chlorinated pesticides are still being detected in fish and wildlife within the Delta and throughout the world.

Effluents from municipal and industrial sources are common components of mainstem rivers entering the Delta Estuary and Bay. These effluent flows may need to be reduced to restore the health of native fish and wildlife by reducing long-term and acute effects that alter aquatic foodwebs and impair the reproductive potential of these species.

ISSUES AND OPPORTUNITIES

CONTAMINANTS IN THE CENTRAL VALLEY: Researchers frequently discover in bioassays that waters and sediments in various parts of the system are toxic to fish and invertebrates. Although there is only limited evidence connecting these conditions to reductions in abundance, this chronic condition does not seem conducive to long-term restoration. Furthermore, there is an ongoing debate over the long-term consequences to human health of chronic exposure to low concentrations of many organic contaminants. Reducing the impacts of toxic contaminants have been elevated to the status of a specific goal for the ERP.

VISION

The vision for contaminants is to ensure that all waters of mainstem rivers and tributaries entering the Bay-Delta, and all waters of the Bay-Delta, are free of high concentrations of toxic substances.

The vision includes preventing, controlling, or reducing damaging levels of high-priority contaminants by remediating mine wastes, minimizing boat discharges and dredging effects, managing flows, restoring habitat, managing watersheds, and supporting existing programs for controlling agricultural and urban point and nonpoint sources.

ERPP recognizes the complexities inherent in defining processes related to toxic substances and biological responses in the Bay-Delta estuary, where processes operate over a wide range of space and time scales and flow regimes. The process of ecosystem restoration would be initiated by implementing actions to prevent, control, and reduce contaminant sources that represent immediate or potential toxicological hazards to ecosystem processes. The following describes actions that would help to achieve the ERPP vision for contaminants.

One goal is to remediate abandoned mines that contribute significant amounts of heavy metals, sediments, acidified water, and other pollutants to tributaries and mainstem rivers, thereby increasing contaminant loading to the Bay-Delta estuary. Water degradation from mine drainage water can be reduced by controlling runoff based on water quality objectives for specific contaminants; regrading, sealing, and reclaiming strip-mined lands by restoring physical habitat; or using biological or chemical inhibitors to reduce acid formation.

If necessary, financial incentives could be provided to farmers who successfully implement practices to reduce contaminant loading in Central Valley waterways. The successful reduction of rice herbicides in the Sacramento River demonstrates that it is possible to successfully control nonpoint-source contaminants through cooperative efforts by farmers and regulators.

Land use conversion for habitat restoration has the potential to help reduce pesticide, herbicide, mineral salt, and trace element loadings. Converting land from agricultural uses to native wetland and upland habitats would reduce the concentrations and loads of contaminants associated with current agricultural uses. Modifying current farming practices in other areas to be more "wildlife friendly" by changing cultivation practices, introducing postharvest flooding, and reducing pesticide and herbicide application rates would also support reductions in contaminants that could affect adjacent aquatic resources.

ERPP also proposes to reduce the concentration of contaminants entering the Bay-Delta and its tributaries by improving drainwater management. Measures could include reusing drainwater, managing groundwater, scheduling releases to the San Joaquin River to coincide with flows sufficiently large to dilute concentration or acquiring dilution flows from willing sellers, installing drainwater evaporation systems, and encouraging on-farm bioremediation using flow-through systems. Potential lands to be evaluated for retirement could include areas where soils drain poorly; overlay shallow, selenium-laden groundwater tables; or are only marginally productive.

Reducing urban and industrial contaminant loading to the Bay-Delta estuary could be accomplished by assisting formation of partnerships between dischargers and regulators. Using this approach, incentives could be provided to encourage improved source control, better urban planning and development, and wastewater recycling projects that reduce contaminants.

Dredging activities should be monitored and practices developed and implemented to reduce the release and resuspension of toxic substances in contaminated sediments and the discharge of contaminated water from dewatering operations. Studies are needed to evaluate opportunities for reuse of dredged material for proposed ERPP and other habitat restoration projects.

Wetlands management should be considered as a possible means to improve water quality by controlling natural, wastewater, and stormwater contaminants. Wetlands can retain contaminants or reduce loadings by converting contaminants through biochemical processes to less-harmful forms; wetlands also stabilize sediments. Without properly managing contaminants, however, wetlands can degrade and subsequently threaten the food chains they support.

Risks of bacterial and viral contamination from domestic wastewater could be reduced by enforcing boat-discharge regulations in the Bay-Delta estuary and tributaries, reducing recreational overuse and building of recreational homes near streams or Delta waterways, and endorsing wastewater reclamation projects.

Point- and nonpoint-source contaminants can be reduced by developing or implementing existing watershed management plans that effectively reduce contaminant loadings affecting ecosystem processes. Management practices that reduce loading include reducing contaminant loading to reservoirs, protecting groundwater, controlling erosion, reclaiming mines, better planning for land use, controlling animal waste, and screening and identifying nonpoint-source contaminants.

Studies are needed to determine if sediments in the Bay-Delta are toxic. Successfully reducing contaminant loadings will require working closely with agencies that have regulatory authority to develop water and sediment quality objectives for contaminants of concern for which none have been set.

INTEGRATION WITH OTHER RESTORATION PROGRAMS

The CALFED Water Quality Program goal is to provide good water quality for environmental, agricultural, drinking water, industrial, and recreational beneficial uses. The water quality program includes programmatic actions to reduce water quality degradation for agricultural drainage, urban and industrial runoff, acid mine drainage, wastewater and industrial discharges, and natural sources which affect Bay-Delta water quality.

The geographic scope of the CALFED Water Quality Program is the legally defined Delta. This program is developing a strategy to resolve water quality problems that affect beneficial uses of the estuary. Included in this strategy is the intent to resolve water quality problems for certain species (e.g., anadromous fish) that inhabit the Delta but may be impacted at different life stages by conditions outside the Delta. In resolving the water quality problems of the Delta, CALFED may undertake actions throughout the ERPP Study Area.

Other ongoing water quality and contaminant monitoring programs are administered by the California Department of Water Resources, State Water Resources Control Board and the regional water quality control boards, U.S. Environmental Protection Agency, U.S. Geological Survey, local water districts, and many other local agencies and organizations. Some of these programs have made significant progress in controlling contaminant loading to the Bay-Delta, primarily by controlling point-source discharges from municipal wastewater treatment plants and industrial facilities. Monitoring programs that identify long-term trends in contaminants found in ecosystem biota have helped to guide restoration efforts. Current programs in the Bay-Delta are beginning to focus on assessing the toxic effects on ecosystem processes, identifying transport and fate of toxic substances, and quantifying ecological responses to toxic substances.

Many agency and organizations are concerned with the quality of water in the Central Valley and have implemented or assist in water quality monitoring and remediation programs. The total list is extensive and a few of the major elements follow:

- National Water Quality Assessment Program
- Clean Water Act
- Porter-Cologne Act
- State Water Resources Control Board's D-1485,1978 Water Quality Control Plan, and 1995 Water Quality Control Plan
- Federal Lead and Copper Rule
- California Nonpoint Source Program.

LINKAGE WITH OTHER ECOSYSTEM ELEMENTS

The presence of contaminants in the Bay-Delta system can adversely impair efforts to restore fish, wildlife, and plant species to a healthy state. The individual species affected vary throughout the system and the adverse effects or presence of contaminants varies as well. For example, juvenile winter-run chinook salmon rearing in the Sacramento River below Keswick Dam can be harmed by heavy metals originating from Iron Mountain Mine. Lower in the system, all aquatic organisms can be adversely effected after storms by runoff of acute levels of pesticides applied in the late winter and early spring to orchards. Riparian communities can be adversely effected by overspray of herbicides.

OBJECTIVES, TARGETS, ACTIONS, AND MEASURES

There are three Strategic Objectives that address contaminants.

> The first Strategic Objective is to reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health.

LONG-TERM OBJECTIVE: Reduce concentrations and loadings of contaminants to levels that do not cause adverse affects on all organisms and ecosystems in the aquatic environment. Reduce contaminant loads in harvested fish, wildlife and invertebrates from the Bay-Delta system so that they are safe for consumption.

SHORT-TERM OBJECTIVE: Reduce concentrations and loadings of contaminants that affect the health of organisms and ecosystems in water and sediments to the extent feasible based on benefits achieved, cost and technological feasibility. Identify major sources of contaminants (e.g., heavy metals) in the flesh of harvested fish and invertebrates to see if reduction in sources of contaminants is likely to reduce contaminant loads in fish, wildlife and invertebrates.

RATIONALE: A wide variety of pesticides including herbicides, fungicides, algicides and other toxic materials enter the aquatic environment of the Bay-Delta from many sources. The number and variety of contaminants entering the rivers and estuary is poorly known, as are their toxic effects, in part because the amounts and kinds are constantly changing. However, there is good reason to think that toxic compounds are having many negative effects on aquatic organisms, both acute and chronic. These same compounds can have effects on human health, so reducing their entry into the aquatic systems should have positive health benefits as well. Reducing concentrations of toxic contaminants in the aquatic environment is not easy because it will require broad changes in land management practices and pest control practices in agricultural and residential areas. It will require reductions in the risk of contamination from pesticide use through reduction in the amount of pesticide applied, and changes in the types of pesticides and methods of application to reduce their ability to contaminate aquatic ecosystems. Changes in industrial practices that result in contaminants being released (e.g., hydrocarbons from oil refineries) will also be required. Many resident fish, wildlife and invertebrates contain high levels of heavy metals and other contaminants, resulting in warnings that their consumption may be harmful to human health. Elimination of this contamination in the short run is unlikely, but systematic reduction of sources may eventually make all harvested organisms in the estuary and watershed safe to eat. In some cases, such as mercury, reduction of loads to safe levels may be extremely difficult because of deposits in sediments and through absorption and bioaccumulation, but strategies to reduce concentrations are still needed.

STAGE 1 EXPECTATIONS: Strategies and financial incentives will have been developed and implemented that reduce the risk of contamination of toxic materials. Examples include the proper use of pesticides within Integrated Pest Management (IPM) frameworks, proper disposal of unused products and containers, and minimization of the movement of pesticides off-site. The monitoring of contaminants should be substantially increased, both as applied and in the environment to get a better handle on what is going where and on the association of contaminants with declines of aquatic species. Annual goals will have been established for the reduction of concentration of selected contaminants in the environment (e.g., carbofuran, chlorpyrifos, diazinon, hydrocarbons, selenium) and monitoring programs set up to determine success of reduction programs. Major sources of contaminants in fish will have been identified and drainage-specific plans developed to reduce their entry into the ecosystems.

> The second Strategic Objective for contaminants it to reduce fine sediment loadings from human activities into rivers and streams to levels that do not cause adverse ecological effects.

LONG-TERM OBJECTIVE: Implement watershed management plans for all watersheds in the Central Valley in the Delta to reduce or eliminate contaminant loads flowing into aquatic ecosystems.

SHORT-TERM OBJECTIVE: Assist existing programs and encourage new watershed management programs to develop watershed management plans to reduce or eliminate contaminant loads flowing into aquatic ecosystems.

RATIONALE: Contaminants from agricultural, industrial, and urban runoff are potentially major sources of mortality to aquatic organisms and can cause damage to aquatic ecosystems that is often hard to detect and regulate. Therefore, the best approach to the regulation of non-point source contaminants seems to be cooperative watershed plans with built-in incentives for reducing contaminant loadings of waterways. any watershed management programs in the Bay-Delta have been successful and they

STAGE 1 EXPECTATIONS: The CALFED Watershed Management Program will assist existing watershed programs and encourage the formation of new watershed groups in achieving these objectives. Using existing data and analyses, major watersheds in the Central Valley will have been rated or ranked according to the amount they are impaired by contaminants. Plans to reduce contaminant loads in at least 10 watersheds for which such plans do not exist at the present time should be developed an implemented.

> The third Strategic Objective for contaminants is to reduce loadings of oxygen-depleting substances from human activities into aquatic ecosystems in the Bay-Delta watershed to levels that do not cause adverse ecological effects.

LONG-TERM OBJECTIVE: Eliminate runoff and discharges that contain undesirable concentrations of animal wastes, sewage, and other substances that can deplete oxygen levels in streams and sloughs.

SHORT-TERM OBJECTIVE: Identify major sources of oxygen-depleting substances throughout the CALFED region and develop strategies for their reduction; reduce the aquatic areas regarded as degraded by animal waste, sewage, and other organic substance.

RATIONALE: As a result of the Clean Water Act, Safe Drinking Water Act, Toxic Substance Act, etc., local, regional, State and federal agencies have greatly decreased the amount of contamination of California's waters by sewage, animal wastes, and other substances that deplete oxygen in the water. These organic materials cause rapid eutrophication, resulting in fish kills and dominance by undesirable organisms. Such contamination, although diminished, is still common and needs to be reduced further, especially from agricultural sources. For example, low oxygen levels in the lower San Joaquin River are often a barrier to the movement of salmon and other fish. It is worth noting, however, that release of organic nutrients into aquatic systems is not necessarily always harmful, especially if the nutrients derived from human sources essentially replace those no longer entering the system from natural sources.

Some East Coast estuaries have experienced problems with pathogens that appear to be related to eutrophication and oxygen depletion. Although there are reasons not to expect these problems in the Bay-Delta system, any indication of such problems should elicit a rapid response to investigate and control these problems.

STAGE 1 EXPECTATIONS: Sources or areas of problem releases of oxygen-depleting substances will have been identified and incentive programs developed to reduce the amount of organic contamination coming from agricultural, industrial, and residential areas.

RESTORATION ACTIONS

The general target for contaminants is to reduce loading, concentrations, and bioaccumulation in the food chain to levels that do not impair other efforts to restore health to fish, wildlife, and plant populations in the ERPP Study Area.

Agricultural point- and nonpoint-source controls on pesticides, herbicides, mineral salts, and trace elements could be achieved using best management practices such as:

- improving irrigation and tillage techniques,
- placing areal restrictions on pesticide spray and using integrated pest management to reduce pesticide use and consequent discharge to waterways during rainstorms,
- improving fertilizer application technologies,
- altering the amount of time pesticides are present, and
- improving water-use efficiencies.

MSCS CONSERVATION MEASURES

The following conservation measures were included in the Multi-Species Conservation Strategy (2000) to provide additional detail to ERP actions that would help achieve species habitat or population targets.

- Restore and enhance delta smelt and longfin smelt habitat to provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (submerged tree roots, branches, rock, and emergent vegetation) in important spawning areas.
- To the extent consistent with CALFED objectives, protect Sacramento splittail spawning areas by providing suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emersed and submersed vegetation).
- Implement applicable management measures identified in the restoration plan for the Anadromous Fish Restoration Program and the recovery plan for the native fishes of the Sacramento/San Joaquin Delta.
- Implement management measures identified in the proposed recovery plan for the Sacramento River winter-run chinook salmon.

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